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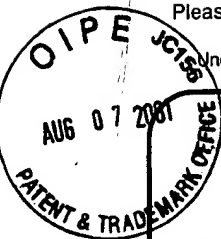
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Specification and Drawings, as originally filed, with Application for Patent Serial No:
2,281,356, on September 1, 1999, by **CATENA TECHNOLOGIES CANADA INC.**,
assignee of Jim Hjartarson, Mark Feeley, Jonathan Boocock, Andrew Deczky and Andreas
Weirich, for "Enhanced Line Card and Packetizing CPE for Lifeline Packet Voice
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L. Lachance
Agent certificateur/Certifying Officer

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ABSTRACT

A voice and data communication system whereby a line card digitizes and packetizes voice communications signals upon the failure of Customer Premises Equipment (CPE). The system comprises a line card for coupling the CPE with a
5 network. Furthermore, the invention provides a system that can direct the voice signals to either or both of a voice network and a data network.

Enhanced Line Card and Packetizing CPE for Lifeline Packet Voice Telephony

The present invention relates generally to the field of Digital Subscriber Lines (DSLs), and particularly to packetized voice access systems.

5

BACKGROUND OF THE INVENTION

Traditionally, telephone service is provided by the Public Switched Telephone Network (PSTN), which consists of a multiplicity of telephone switches interconnected by various transport media and formats (the PSTN transport network), and connected to
10 telephone terminals at subscriber's premises by twisted pair loop wires.

Figure 1 illustrates a traditional circuit switched telephone network, represented generally by the numeral 10. In this example, the PSTN transport network 12 interconnects telephone switches 14. The switches, in turn, interface by means of POTS line cards 16 to individual twisted pair loops 18 and telephone terminals 20. In the case
15 of typical residential telephone service, the POTS line card 16 provides a number of functions required to operate a telephone terminal 20 connected at the subscriber's residence. These functions are often collectively referred to as BORSCHT and usually include, but are not limited to:

- Battery - supplying power;
- 20 Overvoltage - protecting the line card against environmentally caused overvoltages;
- Ringing - supplying a signal which energizes the telephone terminal receiver;
- Supervision - detecting whether a subscriber telephone receiver is on hook or off hook;
- 25 Coding - converting the analog loop signal into digital representation;
- Hybrid - separating the received from the transmitted signals; and
- Termination - terminating the loop with a required standard electrical impedance at the line card.

Although implementation details differ, the B, O, R, S, and T functions typically
30 reside in the Analog Front End 22 and the C, H, and T functions in the Voice Engine 24. The line card 16 supplies power to the telephone terminal 20 from an uninterruptible power supply 26. The power supply 26 is physically situated in the telephone central office and is referred to as the Central Office (CO) Battery. The CO Battery plant is

engineered and sized to supply power to conventional telephone terminals 20 even in the event of a general power outage. Therefore, telephone service is characterized by a high degree of availability, a grade of service referred to as "lifeline" POTS. Typically, a line card 16 is capable of supplying up to 30 mA of current at 48 V to a twisted pair loop 18 and telephone 20. However, the exact value of current depends on the combined electrical resistance of the twisted pair loop 18 and the telephone terminal 20. The exact current limit value is implementation dependent and may range from 20 to 35 mA.

With the explosive growth in data communications, a Multi Service Data Network (MSDN) has evolved which now has more aggregate bandwidth and is growing more rapidly than the PSTN transport network. The data communications network relies on protocols and network elements which enable the routing and switching of collections of bits known as packets or cells. Essentially, each packet/cell can be independently routed or switched by devices known as routers to different destinations based on a destination address contained within each packet or cell. If the packet stream contains digital representations of a voice conversation, routing of these packets represents a function analogous to traditional telephony switching. It should be noted that the term voice is used generically and its definition may be extended to include other analog transmissions such as fax, traditional modems, and the like. In the following descriptions, packets and cells are understood to be analogous entities and, unless specifically indicated, may be used interchangeably and individually without restricting the generality of the description. The terms VoIP and VoATM are to be treated in a similar fashion.

Figure 2 represents the situation described above. In the diagram, a Packet Switched Voice Access Network 30 is shown. The Multi Service Data Network 32 interconnects and routes packets/cells among various Digital Subscriber Loop Access Multiplexers (DSLAMs) 34, which multiplex data streams from multiple DSL Line Cards 36. Each DSL line card 36 interfaces to and communicates over a twisted pair loop 18 to DSL Customer Premises Equipment (CPE). The DSL CPE may be self contained and connected to a source of packet/cell data such as a computer (not shown), may be a DSL Network Interface Card (DSL NIC) (not shown) internal to a computer, or may be a CPE herein called a Voice Packetizing CPE 38. The DSL line card 36 may communicate using any of a number of methods that impress a signal representing a digital bit stream onto twisted pair loops 18 traditionally used to carry POTS signals. These methods

include, but are not limited to, the methods generally known as ADSL (Asymmetric DSL), SDSL (Symmetric DSL), HDSL (High-rate DSL), VDSL (Very high-rate DSL), ISDN (Integrated Services Digital Network), MVL (Multiple Virtual Lines), or CAP (Carrierless Amplitude/Phase).

5 The Voice Packetizing CPE 38 transforms the analog signals from a traditional telephone terminal 20 into voice packets or cells suitable to be carried in a DSL signal on the twisted pair loop 18 from the subscriber's premises. In order to operate a traditional telephone terminal 20, the Voice Packetizing CPE 38 includes most of the functions associated with a traditional telephone switch POTS line card 16 in its Voice Engine 42
10 and Analog Front End 44. Some specific differences from the corresponding POTS line card blocks might include coding to a 16 bit linear digital representation rather than μ -law or A-law, the provision of 24 V rather than 48 V powering of the telephone terminal, reduced robustness to line overvoltages, and the like. The differences do not impact on the nature or significance of functions described below. A Voice over Internet Protocol
15 (VoIP) or Voice over Asynchronous Transfer Mode (VoATM) Engine 46 includes circuits and algorithms for reducing the bit rate of the digitized voice stream received from the Voice Engine 42. The VoIP /VoATM Engine 46 also processes the reduced bit rate stream into packets or cells and may also include an echo cancellation capability for reducing the subjective audible effects of the delay introduced by the coding and
20 packetizing operations. These functions typically implement a set of protocols which may include an embodiment of ITU Recommendation H.323, G.168 or similar standards and algorithms. The packet/cell stream generated by the VoIP/VoATM Engine 46 is transmitted to and received from the DSLAM 34 by means of the DSL modem 40. The DSL modem 40 may implement any of a variety of digital subscriber loop standards,
25 such as ITU Recommendation G.992.1 ("Full rate ADSL") or G.992.2 ("ADSL lite").

Because the circuits contained within the Voice Packetizing CPE 38 require more power than can typically be provided by a Line Card 36, they are typically powered by means of a power supply 48 which derives its power from the local AC mains. If a local power outage disrupts AC mains power, communication using the Voice Packetizing
30 CPE is not possible until AC mains power is restored. This is problematic for subscribers accustomed to telephone service being available despite power outages, and especially in case of a life or security threatening emergency situation. Uninterruptible AC power

supplies (UPS) are commercially available which will provide AC power for a short time in the event of a local AC mains power outage. However, the disadvantages of local UPSs are the purchase cost, the limited time these devices can supply power, and the regular maintenance that is required to ensure they are operational in the event of a power
5 outage.

Further, in conventional packet based networks, provision of lifeline packet voice service requires up to 3 separate pieces of equipment: a DSLAM, POTS Access Equipment such as a Digital Loop Concentrator, and a Gateway. The Gateway is a piece of network equipment that provides a translation and mediation of voice and signaling
10 signals and protocols between the PSTN and the MSDN. The need for three separate pieces of equipment increases overall network and equipment complexity and complicates service provisioning and maintenance.

It is an object of the present invention to obviate or mitigate at least some of the above disadvantages.

15 SUMMARY OF THE INVENTION

In general terms, the present invention provides a voice and data communication system whereby a line card digitizes and packetizes voice communications signals upon the failure of Customer Premises Equipment (CPE). The system comprises a line card
20 for coupling the CPE with a network. The aforementioned line card includes:

an analog front end for coupling the line card to the CPE;

a digitizer for digitizing the received voice signals;

a packetizer for packetizing the digitized voice signals;

a modem for transmitting the packets; and

25 a system interface for coupling the line card to at least one network.

Furthermore, the invention provides a system that can direct the voice signals to either or both of a voice network and a data network. The system comprises a line card including

an analog front end for coupling the line card to a telephone;

30 a digitizer for digitizing the received voice signals;

a packetizer for packetizing the digitized voice signals;
a modem for transmitting the digitized voice signals to the data network;
a system interface for coupling the line card to the voice network and the data
network;
5 a controller for controlling the destination of the voice signal.

BRIEF DESCRIPTION OF THE DRAWINGS

An embodiment of the invention will now be described by way of example only,
with reference to the accompanying drawings in which:

- 10 **Figure 1** is a block diagram of a traditional circuit switched telephone network
interface;
Figure 2 is a block diagram of a conventional packetized voice access system;
and
Figure 3 is a block diagram of a lifeline packetized voice access system.

15

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

For convenience, like structures in the drawing are referred to using like
numerals.

- Figure 3 illustrates a Lifeline Packetized Voice Access system, which is
20 represented generally by the numeral 60. The system 60 enables a lifeline grade of
service to be offered for packetized voice telephony using either a Lifeline Packetizing
Voice (LPV) CPE 62, as described below, or a conventional analog telephone terminal
20.

- The LPV CPE 62 contains functional blocks comprising a conventional voice
25 packetizing CPE 38 as previously described and illustrated in Figure 2. Specifically, it
comprises a DSL modem 40, VoIP or VoATM Engine 46, Voice Engine 42, and an
Analog Front End 44, as well as the Power Supply 48. Additionally, the LPV CPE
contains an optional POTS splitter 78, enabling a telephone terminal 20 to be connected
to the twisted pair 18 through a relay 80. The common contacts of the relay 80 are
30 connected to the telephone terminal 20, and the normally closed contacts are connected to
the POTS Splitter 78. The relay is energized by a DSL Synch Detect signal 76 from the
DSL modem within the voice packetizing CPE 40.

Under normal conditions, that is when the AC mains power to the Lifeline Packetizing CPE is present and the DSL modem is synchronized to a valid DSL signal on the twisted pair loop, the DSL Synch Detect signal is asserted and energizes the relay 80. When the relay 80 is energized, the common contacts are connected to the relay's

5 normally open contacts. Therefore, the telephone terminal 20 is connected to the voice packetizing CPE 38, causing voice communications to occur by means of a digital packet/cell stream over a DSL signal through the DSL Modem 35 of the LPV Line Card 66, and to the MSDN 32.

If, however, local power to the Lifeline Packetizing CPE 62 should fail, or the

10 DSL Modem 40 component of the voice packetizing CPE 38 does not detect a valid DSL signal, the DSL Synch Detect signal 75 is negated and de-energizes the relay 80. Therefore, the telephone terminal 20 connects through the normally closed contacts of the relay 80 and the POTS Splitter 78 to the twisted pair loop 18. In this state, the telephone terminal is directly connected to the twisted pair (through the POTS splitter 78) and

15 powered from the CO battery through a Broadband Analog Front End (BAFE) 72 on a Lifeline Packet Voice Line Card (LPVLC) 68. Voice communication takes place through a Voice Engine 24 and a VoIP/VoATM Engine 46 on the line card 68, in a packetizing voice line card fashion.

A number of Lifeline Packet Voice Line Cards (LPVLC) 66 are contained within

20 appropriate access equipment 68. The equipment 68 could be a Digital Loop Carrier system, a voice-capable DSLAM, a data-capable digital telephony switch, or the like.

The Lifeline Packet Voice Line Card 66 contains circuitry for interfacing to both an analog telephone terminal and a DSL-based CPE. A system interface 70 contains circuitry to interface both to the Public Switched Telephone Network (PSTN) 12 and the

25 Multi Service Data Network (MSDN) 32. The interfaces described here are conceptually identical to their respective interfaces shown in Figure 1 and Figure 2. The Voice Engine 24 and DSL Modem 35 are identical to the respective blocks in Figure 1 and Figure 2. The Broadband Analog Front End 72 combines the functionality of the voice only Analog Front End 22 of the POTS Line Card in Figure 1 and the DSL Front End 37 of

30 the DSL Line Card in Figure 2. The Broadband Front End 72 provides the B, O, R, S, and T functions over the full bandwidth required to support both voice and DSL signals,

and satisfies the distinct requirements of both DSL and POTS interface types, with regard to termination impedance, drive levels, linearity, and loop powering.

The VoIP or VoATM Engine 46 performs the identical function as previously described and depicted in the Voice Packetizing CPE 38 of Figure 2. The Engine 46
5 takes the digitized voice from the voice engine 24, performs compression, packetization, and, optionally, echo cancellation. The resulting voice packets are sent to the system interface 70, where they may be merged with the packet/cell stream from the DSL modem block 35. This merging function may be implemented in the LPVLC or elsewhere in the Access Equipment 68. The merging is controlled by the merge
10 controller 74, which produces a merge signal. The merge signal 75 is sent to the Voice Engine 24, the VoIP Engine 46, and the System Interface 70 blocks. The merge controller 74 may be configured to operate in several modes described as follows. If the merge control signal 75 is permanently on, the system is in Packetizing Voice mode. The line card 66 will packetize the voice signals and direct the resulting packet stream to the
15 MSDN, while powering a conventional telephone terminal 20. If the merge control signal 75 is permanently off, the system is in POTS only or Packetizing CPE only mode and the line card 66 will not packetize the voice signals. However, the merge control signal 75 may also be responsive to a DSL Synch Detect signal 76 produced by the DSL Modem 35 whenever a valid DSL signal originating from the subscriber CPE is detected.
20 This mode is referred to as Lifeline Packetizing CPE mode. The line card will packetize the voice signals and direct the resulting packet stream to the MSDN, while powering a conventional telephone terminal when the CPE is unable to.

The Lifeline Packet Voice Line Card 66 is therefore capable of performing the function of a traditional POTS line card as shown in Figure 1, or of a DSL line card as
25 shown in Figure 2. When operating as a DSL line card 36, the Lifeline Packet Voice Line Card 66 may be part of a conventionally defined VoIP or VoATM system, where the voice packetization is performed at the CPE. The access equipment 68 in such a system does not process or alter the content of the packets or cells in the VoIP or VoATM stream, but merely provides an appropriate transport for the VoIP or VoATM
30 stream from the subscriber to the MSDN 32.

The Lifeline Packet Voice Line Card 66 is also capable of operating as a packetizing voice line card. In this mode, the LPV Line Card 66 provides an interface for

a conventional telephone terminal 20, through the BAFE 72 and the Voice Engine 24. Therefore, if the power has failed at a subscriber premises, the telephone terminal is powered conventionally through the BAFE 72 from the Central Office (CO) battery (not shown) and can still transmit a voice signal to the line card 66. The Voice Engine 24 on the line card 66 digitizes the voice signal which is then packetized by the VoIP/VoATM Engine 46. The resulting packet/cell stream is delivered through the system interface 70 to the MSDN 32. Since the telephone terminal is powered from the CO, and the voice signal is delivered as a packet/cell stream to the MSDN 32, the net result is a packet voice communications capability with a lifeline grade of service.

To this point, the system has only been described as if powering and communicating with a telephone terminal and voice packetization are necessarily a function mutually exclusive with DSL communication. However, the system definition may also be extended to provide DSL communication on the same loop and simultaneous with a POTS interface. Simultaneous DSL and POTS capability on a single loop is defined in the ITU Recommendations for ADSL, for example, but is not necessarily possible for any other type of DSL modem or modulation scheme.

Referring once again to Figure 3, a telephone terminal 20 and DSL modem 82 both communicate on the same loop 18 to the access equipment 68 through a POTS splitter 84. In some circumstances the splitter 84 may be optional. Typically, data from the DSL CPE 82 and voice signals from the telephone 20 would communicate on the same loop 18. The signals are filtered by the BAFE 72 after which the voice signal is directed via the Voice Engine 24 and system interface 70 to the PSTN 12. The data signal is directed to and demodulated by the DSL modem 35 and the resulting data packet/cell stream is directed via the system interface 70 to the MSDN 32. Both voice and data processing are, therefore, simultaneously possible on a single line card.

Alternatively, once the Voice Engine 24 has digitized the voice signal, the VoIP/VoATM Engine 46 may be used to packetize the digitized voice signal and have the system interface 70 merge it with the data from the DSL modem 35. The merged stream would be sent over the MSDN. In order to provide simultaneous Lifeline Packet Voice and data communications capability over the DSL to the MSDN, the system interface 70 includes a packet or cell multiplexing capability. The multiplexer enables the merging of the voice packet or cell stream from the VoIP/VoATM Engine 46 with the

packet or cell stream from the DSL Modem 35. As previously mentioned, the merging function may be implemented in the LPVLC or elsewhere in the Access Equipment 68. The multiplexer also enables the diverging of the voice packet or cell stream from the MSDN so that the appropriate streams are sent to the VoIP/VoATM Engine 46 and DSL
5 Modem 35 respectively.

Therefore it can be seen that the Lifeline Packet Voice Line Card 66 has the capability to direct the output of the Voice Engine 24 to either the PSTN 12 or, via the VoIP/VoATM Engine 46 to the MSDN 32, or simultaneously to both. The decision as to where to direct the voice packet stream can be made on a call-to-call basis. The
10 capability to redirect the call exists at any time, for example during a power failure and/or a network connectivity failure. The line card 66, therefore, has the capability to rapidly alter the path a voice connection takes through either the PSTN or the MSDN.

As a result of the architecture used, the system may be able to provide higher quality audio encoding, referred to as Enhanced Packet Voice. Enhanced Packet Voice is
15 not always possible to provide due to the difficulty in providing increased transport bandwidth between the voice coder and packetizer, which may be in physically different and geographically dispersed equipment. Since the architecture in this embodiment of the invention utilizes a voice coder 24 and a packetizer 46 on the same card, Enhanced Packet Voice may be implemented.

Enhanced Packet voice is achieved by providing an alternate, higher quality coding function in the Voice Engine 24 and in the VoIP/VoATM Engine 46, optionally coupled with a capability to code audio frequencies outside the traditional 300 to 3,400 Hz bandwidth of toll quality voice. Alternatively, it may also be implemented in the corresponding components at the CPE 62.
20

Enhanced Packet Voice is useful in applications such as audio conferencing and echo cancellation, where the non-linearity of conventional μ -law or A-law code results in a reduced effectiveness of those algorithms processing the coded voice or voice band signal. Examples of alternate coders for the Voice Engine are 16-bit linear coders, coders with a higher than usual sampling rate, and coders that are both 16-bit linear coders and
30 have a higher sampling rate. The reduction of effectiveness is typically, although not exclusively, due to nonlinear coding yielding a reduced quality of coding of a desired signal when a stronger, undesired signal is present.

Examples of alternate coders for the VoIP/VoATM Engine include perceptual coders defined for studio or CD quality audio. An alternate, higher quality coder generally results in a higher packet/cell rate from the VoIP/VoATM Engine.

5 Although the invention has been described with reference to certain specific embodiments, various modifications thereof will be apparent to those skilled in the art without departing from the spirit and scope of the invention as outlined in the claims appended hereto.

**THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE
PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:**

- 1) A voice and data communication system comprising a subscriber premises equipment
5 (CPE) and a line card for transferring communication signals between a customer and
a network, said line card comprising:

an analog front end for coupling said line card to said CPE

a digitizer for digitizing received voice signals;

a packetizer for packetizing said digitized voice signals;

10 a modem for transmitting the packets; and

a system interface for coupling said line card to at least one network;

wherein said line card digitizes and packetizes said voice signals upon failure of
said CPE.

- 2) A system as defined in claim 1, said CPE comprising:

15 a digitizer for digitizing received voice signals;

a packetizer for packetizing said digitized voice signals; and

a switch for bypassing said packetizing system to a Plain Old Telephone System
(POTS).

- 3) A system as defined in claim 2, wherein said switch is a relay for switching between
20 said packetizer and said POTS system.

- 4) A system as defined in claim 3, wherein the position of said switch is determined by a
signal, said signal indicating the status of the connection between said CPE and said
line card.

- 5) A system as defined in claim 1, wherein said modem is a Digital Subscriber Line
25 (DSL) modem.

- 6) A system as defined in claim 2, wherein said line card packetizes said voice signals
because said subscriber is unable to, and said CPE digitizing and packetizing
equipment is bypassed.

- 7) A system as defined in claim 2, wherein said failure is a power failure at said subscriber's location.
- 8) A system as defined in claim 2, wherein said failure is the inability to synchronize a DSL modem on said CPE with a DSL modem on said line card.

- 5 9) A system as defined in claim 2, wherein said digitizers provide high quality audio encoding.
- 10) A system as defined in claim 2, wherein said packetizers provide high quality audio encoding.

- 10 11) A system for providing a voice signal for transmission comprising a line card for receiving said voice signal from a telephone, said line card including:
- an analog front end for coupling said line card to said telephone;
 - a digitizer for digitizing received voice signals;
 - a packetizer for packetizing said digitized voice signals;
 - a modem for transmitting said digitized voice signals to a data network;
 - 15 a system interface for coupling said line card to a voice network and said data network;
 - a controller for controlling the destination of said voice signal;
- wherein said system can provide said voice signals to said voice network and said data network.

- 20 12) A system as defined in claim 11, wherein said line card receives a data signal on the same loop as said voice signal, said analog front end separates said data signal from said voice signal, and said modem transmits said data signal to said data network.

- 13) A system as defined in claim 11, wherein said modem is a DSL modem.

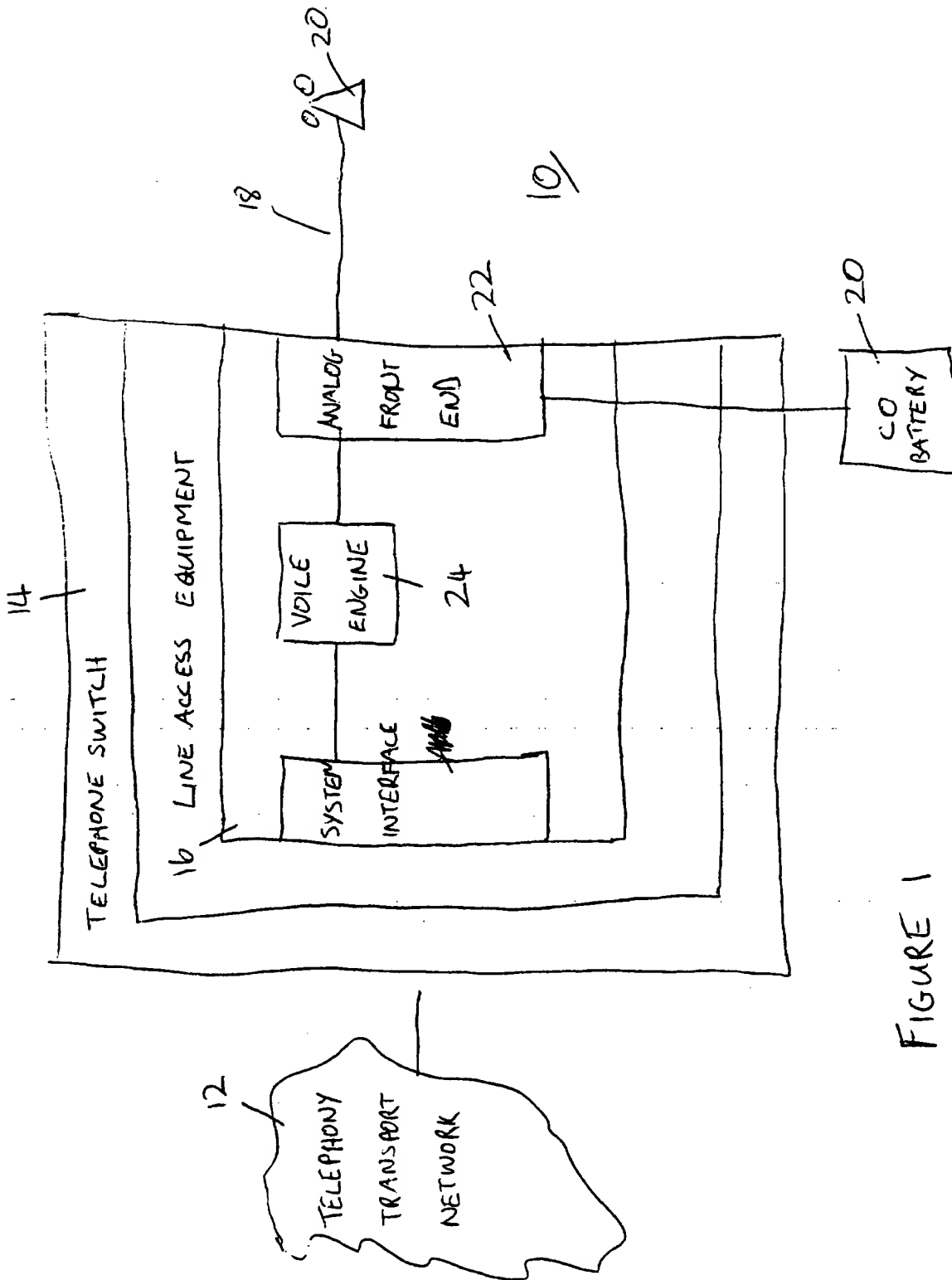


FIGURE 1

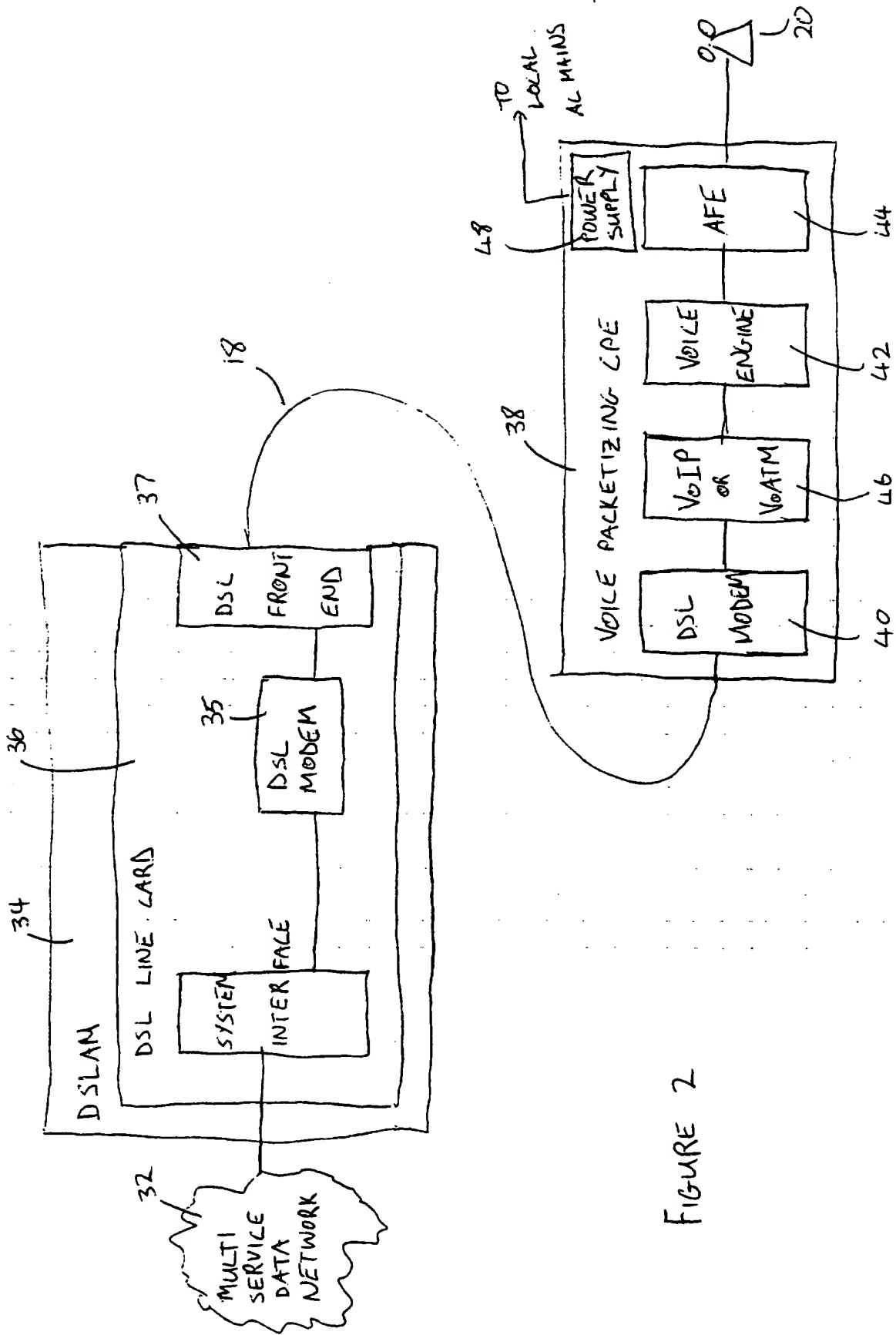


FIGURE 2

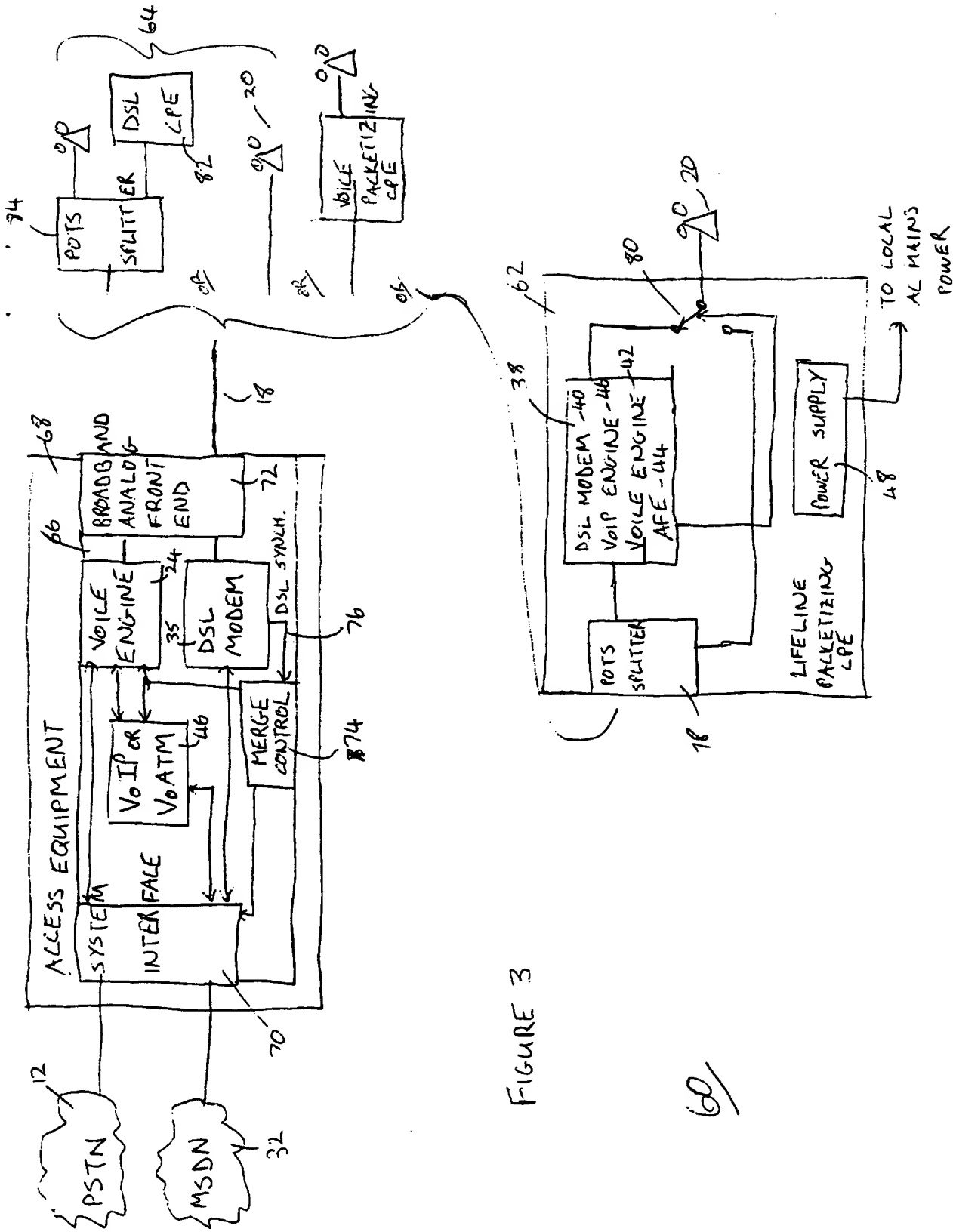


FIGURE 3

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